IP Inter-Carrier Routing

Capabilities to Support IP Services Interconnection

The Need for IP Interconnection

Service providers have been transitioning their individual networks to IP for many years. The industry has now come to a critical point where key decisions and capabilities are required to support IP based interconnection, and thereby enable growth of wide-scale and end-to-end IP services. The industry has been exploring ENUM based telephone number registries for a number of years and although not deployed, these experiences will be useful as the industry begins to conceptualize the future IP 10-digit line level database. A number of initiatives have recently been created to take the transition to all-IP networks to the next step.

It should be noted that ENUM has found a niche to determine a unique Service Provider ID (SPID) for routing SMS (short message service) and MMS (multimedia message service) over IP, but ENUM is not yet used in the US for the exchange of routing data between service providers to support real-time IP services on a nationwide scale.

Key market drivers are the ongoing deployment of LTE, and the need to provide interoperability, roaming, and IP based interconnection for the new Voice over LTE (VoLTE) and High Definition (HD) voice services that are being launched worldwide.

The GSM Association (GSMA) and the i3forum recently launched an IP interconnection initiative to drive the deployment of VoLTE and new high quality IP communication services through commercial pilots with leading mobile and fixed providers including Deutsche Telecom, Vodafone, Orange, and Telefonica.

In the US, the FCC is driving towards the sunset of the PSTN and has launched a set of service based experiments and data collection initiatives aimed at evaluating the impacts on consumers and businesses of replacing the existing copper-based telephone network with IP based alternatives for broadband, video, data, and voice services. The challenge is to support secure, reliable, and innovative communications services while ensuring public safety, widespread and affordable access, competition, and consumer protection.

Part of this challenge is to enable open access to IP services from a large number of providers to encourage innovation, competition, and a wide array of choice for consumers and businesses.

Enabling IP Interconnection

Although converged communication in an IP environment has long been a prevailing catchphrase in the telecommunications industry, there have been many roadblocks to achieving seamless interoperability between service providers that the industry is now starting to address.

In addition to the GSMA, i3forum, and FCC initiatives mentioned above, ATIS, the North American organizational partner for 3GPP, and the SIP Forum announced a joint task force in

January 2014 to fully specify an IP communications Network-to-Network Interface (NNI) between North American service providers. The goal is to ensure all service interconnection between providers can occur at the IP level end-to-end, including wide-scale IP-based voice services and other ubiquitous advanced real-time communications such as high-definition voice, point-to-point video calling, and multimedia text across wireless, wireline and cable providers.

Although telecommunications users are identified in different ways for different services (e.g., telephone number, email address, internet domain name, location routing number), telephone numbers remain a ubiquitous mechanism for subscribers to find each other. ENUM (E.164 Number mapping) enables participating service providers to map subscribers' phone numbers to a variety of IP attributes and services. A registry service that enables this mapping is an important element of IP intercarrier routing.

Any registry service that provides these mappings also needs to provide three essential capabilities:

- **Policy** - allows trusted interconnect partners to share certain interconnect and routing information with each other to obtain interconnect and routing data. This can be accomplished during the provisioning process.
- **Rules** – provide the ability to aggregate the telephone numbers into a grouping, e.g., OCN, NPA-NXX, LRN, etc., or assign different attributes to a telephone number. This functionality occurs within the registry and the results of the "rules" are either provided in the download to each operator or by per session query.
- **Peering** - allows for multiple registry providers to synchronize with each other and offer the same authoritative data to their respective customers. Enabling competition amongst registries will ensure a more resilient and innovative service with market based pricing

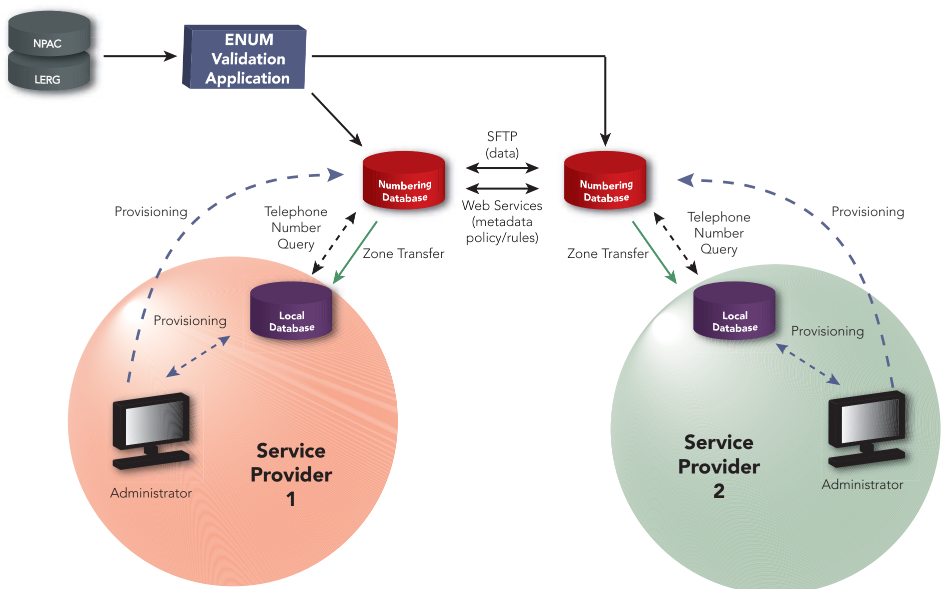

Figure 1 - Peering Registry Reference Architecture

Figure 1 is a reference architecture of the registry that depicts the mechanism by which information is provisioned, distributed, and how multiple registries can co-exist.

IP Interconnection Registry Policy

The US industry is driving towards IP interconnection on a nationwide basis. Unlike the legacy PSTN where the originating network determines the route, IP interconnection may have different characteristics compared to TDM. For example, service providers will be responsible for getting traffic to and from aggregation points where it will be exchanged with other carriers. This would require that an IP Interconnection Registry not only support the interconnection points but also understand, acknowledge and honor the commercial interconnection agreements between service providers.

In an all-IP environment the Service Provider that provisions the data will also likely define one or more selective lists of Data Recipients so that data is not given to unauthorized parties. Therefore, service providers determine the content of the Name Authority Pointer (NAPTR) records returned in response to ENUM queries, including the Uniform Resource Identifier (URI) information that specifies how IP sessions should be routed. Similarly, the Business Logic provisioned by the Service Providers determines the contact information in Session Initiation Protocol (SIP) messages returned to SIP Proxies so that calls can be routed using SIP signaling.

Another example of policy would allow for different Name Server records; depending on the originating & terminating service provider combination, the registry could be configured with policy for source based resolution using a "Recipient Group" feature. For example, some authorized Service Providers of Record might input Name Server information for the same TN that in one case refers to the Tier 2 Name Server of a transit operator or Internetwork Packet Exchange (IPX) and in another case refers to their own terminating Tier 2 Name Server when they are peering or interconnecting directly with the originating service provider. While more powerful in the Tier 2 Name Server platform, this feature has potential application at the registry level and could be used for either per session queries as well as to customize the data download to local cache.

IP Interconnection Registry Rules

The number of records stored in an IP Interconnection Registry could be tens or hundreds of millions based on the need to assign different characteristics per TN. A single change can ripple through the data and touch a vast number of records. As Service Providers provision their Destination Codes, such as Telephone Numbers (TNs), Local Routing Numbers (LRNs), 1K NPA (Numbering Plan Area)-NXX-X number pool blocks, or 10K NPA-NXX exchange codes, these records would identify a routing pattern. A rule that aggregates a number of TNs into a block such as NPA-NXX or NPA-NXX_X can dramatically reduce the number of records that need to be provisioned because it enables higher-level groupings that provide a compressed record set.

For example, an NS or NAPTR record value could be assigned to each Operating Company Number (OCN) rather than to each telephone number or, to each unique Service Provider ID (SPID) and/or NPA/NXX or Location Routing Number (LRN). This could also differ by TN and be at the discretion of the number holder.

As the migration to IP occurs, a single telephone number may be associated with several services, e.g., HD voice, Instant Messaging (IM), and IP telephony. Consequently, when a telephone number is dialed, the service provider needs to know how to route the call. In the example of HD voice (using G722 or G722.2 codecs), if an end user calls from a HD device and the call is terminated on a HD device, the quality of the call should not be downgraded to traditional voice (G711). The issue is that not all border gateways/session border controllers are HD-capable and not all service providers are HD-capable and consequently this becomes a question of capital investment. The originating service provider should have the ability to route the call to an HD-capable gateway all the way at the far end. However, if the terminating network cannot complete the HD session, then there is no reason to use the more expensive HD codecs. Therefore, the network needs to associate that destination number with some "HD capable" flag.

Not all subscribers have the same services. Therefore, the calling network needs to determine whether the called party has the requested service prior to setting up the call. A solution would be to publish the service information for end users in a registry. A purpose-built registry can accommodate various service attributes at a TN level as well as at coarser levels based on rules established by the Service Provider. The use of rules allows the industry to provision services against higher levels of abstraction which optimize the number of records in the registry and especially in a local (cache) database. Every record and every digit used to identify the record(s) could drive increased costs across the industry.

The registry could optionally be used by service providers to capture and exchange NAPTR records instead of just NS records thereby combining Tier 2 functionality in the Tier 1 Registry. This would limit the number of external cross network queries. This could be optional according to terminating service provider discretion and would be transparent to the originating service provider. This would enable ENUM implementation without the complexity of cross network queries.

IP Interconnection Registry Interworking

Another issue to address is the examination of the often-heard statement that there can be "no more than one National ENUM Registry" because of synchronization issues.

The situation with operating multiple ENUM Registries is different than that of operating a distribution infrastructure, such as the Domain Name Server DNS (A.ROOT-SERVERS.NET through M.ROOT-SERVERS.NET), since these Registries are assumed to be independently managed by competing organizations, each of which allow changes to be made to data. Unlike the DNS system, there is not a single source of valid data. It is important to be clear that each of the competing Registries is intended to contain the same data. The issue, then, is to create an architecture that allows propagation of changes with high speed and high precision, to achieve sufficient synchronization capability such that the information within each registry is identical over a sufficiently rapid time scale.

One obstacle to achieving synchronization is the quantity of data involved. The number of records stored in a registry could be tens or hundreds of millions. Clearly, the time taken to distribute a large number of changed records puts a lower bound on the time scale over which the Registries can be considered to be synchronized. However, it is often not necessary to distribute the changed records explicitly. The simple change which impacted the vast number of records can be described by an equally simple rules statement, which can then be compactly and quickly distributed. It is necessary only that:

- Each registry includes a policy language and rule set that operates on the data's metadata, unambiguously and completely describing the changes
- Each registry uses the same policy language in conjunction with the established rules to describe changes sent and to interpret changes received

Figure 1 is a reference architecture of the proposed solution, consisting of multiple peered Registries combined with either cached data in each Service Provider's environment or allowing a query per session.

This figure shows the overall solution, in which the Service Providers provision data in their registry of choice. In addition, the Registries also receive Industry Data from the Number Portability Administration Center (NPAC) and Local Exchange Routing Guide (LERG). The Registries stay in sync by means of two mechanisms: File Transfer Protocol (FTP) and Web Services.

The FTP-based component relies on a file naming convention and an agreed-upon directory structure which is consistent over all participants. The file names contain an identifier for the intended recipient and a timestamp. In addition, the files are named either ALL or INCR. The INCR (Incremental) files contain only changes to data made during the last hour, whereas the ALL files are a dump of the entire database, written every 24 hours. Each file contains a Transaction ID which acts as an index to the stream of changes. Files are written by the sending registry to the FTP site and pulled by the receiving registry as desired.

In addition there is a Web Services component which provides near-real-time response. Each registry commits to exposing changes on the Web Services interface within a matter of seconds, and other Registries poll the interface as often as desired, typically every 15 seconds. Each Web Services query specifies a Transaction ID, so that the server knows the starting point from which changes are required for that specific query. Each response to a Web Services query specifies a "next" Transaction ID which will be used in a subsequent query. Thus there is assurance that every change is transmitted in a stream of linked queries and responses.

It is assumed that the Web Services client will continually poll the server, but if for some reason the client goes silent for some time, the stream is not broken. All that happens is that the next query after a long hiatus will receive a long response.

The Web Services mechanism is well-suited to transmitting relatively small messages on a rapid schedule, such as the rules declaration messages referred to above. The FTP mechanism is well suited to transmitting large numbers of explicit changes by "brute force" if required. This is primarily intended to be a mechanism used during startup or recovery, but a convention might be that ALL explicit data is transferred via Secure FTP (SFTP) (regardless of quantity) and the Web Services mechanism is ONLY used for rules declarations.

Of course some changes are more compactly described by sending the actual data, rather than forcing it into a contrived rules-based description. Thus a convention would be needed to distinguish actual changed data from rules statements which describe changes if Web Services are used to carry both.

In addition, the possibility of collisions must be considered, in which two independent changes are made in different Registries within the synchronization timescale. Each registry must be prepared to roll back changes if it receives instructions from another registry which impact a datum which has just been changed locally.

As the migration to a service rich IP environment occurs, multiple ENUM registries can co-exist and it is important to enable peering capability. As an example, this overall architecture already exists within the TV White Spaces industry. The Whitespaces Database Administrators (WSDBA) group has defined an architecture and an Interoperability Specification (http://apps.fcc.gov/ecfs/document/view?id=7520963472) which allows a number of WSDBAs (several of which are certified by the FCC and actively interoperating) to accept registration information and distribute it quickly and accurately, thereby remaining synchronized.

Summary

As more and more telecommunications services are designed for, or migrate to, IP (e.g., VoIP, VoLTE, high definition voice, messaging, and M2M communications), an authoritative means for identifying telecommunications users and services reachable via IP will become a prerequisite to operate at scale. A platform for provisioning and exchanging this interconnection information between telecommunications providers is needed.

Although telecommunications users are identified in different ways for different services (e.g., telephone number, email address, internet domain name, location routing number), telephone numbers remain a ubiquitous mechanism for subscribers to find each other. ENUM has been used in telecommunications for many years but now needs to evolve to meet the particular needs of inter-carrier routing. As the breadth of available services increases, a standards-based mechanism will be needed for mapping a telephone number into IP addresses designating service-specific interconnection points. This capability will be required as part of any large-scale, service-rich IP interconnection architecture. A trusted, centrally-managed IP interconnection registry for inter-carrier routing of IP enabled services should provide three essential functions; policy during the provisioning process, rules based on routing granularity, and the ability to support multiple competing IP interconnection registries. These practical enhancements to today's ENUM solutions will enable the industry to manage inter-carrier routing on a nationwide scale and ultimately sunset the PSTN.

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